The experimental modelling of mercury desorption in estuaries

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Mercury is a very hazardous pollutant due to its toxic properties. High mercury concentrations in water lead to its accumulation in aquatic biota, as fish and other food products. In river waters mercury migrates only partially in dissolved condition because of its strong sorption on organic particulate matter. In the river and sea water mixing zone mercury forms a strong chloride complexes. Therefore, it is possible to expect the increase of dissolved mercury concentrations by desorption induced by chloride complexes formation. Mercury behaviour in estuaries is determined by many chemical, biological and hydrological processes. So, it is difficult to reveal the sorption processes contribution by the data of natural observations (Coquery *et al.*, 1995; Leermakers *et al.*, 1995; Menasveta, 1978; Mikac *et al.*, 1989). This study describes the results of experimental modelling of mercury sorption-desorption equilibrium between the major clay minerals and solutions imitated fresh water and sea water mixtures.

Methods

Filtrated water from Moscow River and samples of clay minerals (kaolinite, montmorillonite and illite) were placed in the flasks during five days until the sorption equilibrium was reached. After that different quantities of distilled water and 70‰ seawater were

TABLE 1. Mercury sorption on clay minerals at solutions with different chlorinity

Cl ‰	Dissolved Hg μg/l	Hg adsorption μg/g	K_d 10^3 ml/g	Desorption %
Kaolinite				
0	11.7	13.3	1.14	0
1.94	14.8	10.2	0.69	23.3
3.87	16.1	8.9	0.55	33.1
7.75	17.1	7.9	0.46	40.6
11.62	17.6	7.4	0.42	44.4
15.50	18.0	7.0	0.39	47.4
19.37	18.3	6.7	0.37	49.6
Montmorillonite				
0	6.1	18.9	6.10	0
1.94	10.8	14.2	1.31	24.9
3.87	14.4	10.6	0.74	43.9
7.75	16.5	8.5	0.51	55.0
11.62	18.7	6.3	0.34	66.7
15.50	19.2	5.8	0.30	69.3
19.37	20.1	4.9	0.24	74.1
Illite				
0	10.1	14.9	1.48	0
1.94	13.3	11.7	0.88	21.5
3.87	15.1	9.9	0.66	33.6
7.75	16.6	8.4	0.51	43.6
11.62	17.0	8.0	0.47	46.3
15.50	17.3	7.7	0.45	48.3
19.37	17.2	7.8	0.45	47.7

added. The final volume of each mixture was equal to 200 ml, the weight of clay mineral samples was equal to 200 mg. Initial mercury concentration in solutions after addition of distilled water and 70‰ seawater was equal to 25 µg/l. The suspensions were subjected to mixing during three days and after that they were filtrated. Mercury concentration was determined by flame atomic spectrophotometry. Detection limit was equal to 0.2 µg Hg/l and average standard deviation was equal to ± 0.14 µg Hg/l.

Results and discussion

The results of experiments are given in Table 1. Montmorillonite has the largest mercury adsorption value (18.9 µg Hg/g) in comparison with kaolinite (13.3 µg Hg/g) and illite (14.9 µg Hg/g) in the experiments with river water. Increase of chloride concentrations results in the increase of dissolved mercury concentrations due to desorption from clay minerals. Mercury desorption increases more than two times when chloride concentration increases from 1.94 to 19.37‰: 21.5 and 47.7% for illite, 23.3 and 49.6% for kaolinite, 24.9 and 74.1% for montmorillonite.

The distribution coefficient (K_d) is a characteristic of equilibrium between dissolved and sorbed species:

$$K_d = C^*_{Hg} / C_{Hg}$$

where C^*_{Hg} is the sorbed mercury concentration, µg/g; C_{Hg} is the dissolved mercury concentration, µg/ml. The distribution coefficient is equal to 6100, 1480 and 1140 for montmorillonite, illite and kaolinite respectively in the experiments with river water. The distribution factor reduces with salinity increase, and its difference between clay minerals decreases too (K_d = 450–240 at chloride concentration equal to 19.37‰ for all used clay minerals).

Basing on the results of the experiments one can suggest that mercury desorption from clay minerals is important source of dissolved mercury in estuaries. It is possible that the sorption-desorption equilibrium is the major cause of non-conservative mercury behaviour in river and sea water mixing zones.

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References

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